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THE EFFECTS OF LOW TEMPERATURES OF JANUARY 1937 ON FOREST INSECT INFESTATIONS OF THE FOLLOWING SEASON IN THE MODOC NATIONAL FOREST, CALIFORNIA

by
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In California, particularly in the northern part of the state, the minimum temperature records at many Weather Bureau stations were broken and new and lower records were established by two periods of unusually low temperatures that occurred in January, 1937. The record at Hackamore, in the Modoc National Forest, reached close to -35° F. on January 7 although that record cannot be considered exact because of failure of the thermograph to record properly at the time the lowest temperatures occurred. On January 8 an accurate record showed a minimum temperature of -29° F. Low temperatures again were recorded on January 19 (-26°) and January 20 (-23°). On the coldest day, thermograph bulbs imbedded in the bark of trees infested by the western pine beetle recorded temperatures as low as -9° F.

BROOD MORTALITY

Temperatures as low as those listed above are of sufficient intensity to cause mortality in overwintering forest insect populations. A reconnaissance of the effects on forest insect populations in northeastern California was made by A. S. West, Jr. and the writer in April, 1937 (5)*. It was found that broods of all of the species of forest insects that were examined suffered some mortality due to the cold. However, the western pine beetle (Dendroctonus brevicomis Lec) broods were the only ones in which a relatively high mortality rate occurred over most of the area in which the temperatures were sufficiently low to have some effect.

INJURY TO LIVING TREES

In addition to the mortality in forest insect populations it was evident that living trees also had been injured by the cold. (4). Throughout northeastern California, reproduction was injured. The foliage was burned and on many small trees the cambium was damaged. All gradations of injury occurred, the extreme resulting in almost complete defoliation or death during the following summer. A limited amount of this same type of injury to reproduction occurred following the freezes of December, 1932 and February 1933. However it was neither as severe nor as general as that resulting from the low temperatures of January 1937.

The cold also injured the foliage and cambium of mature trees.

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* Figures in parentheses refer to reports listed at the end of this paper.

In the Modoc, many trees, scattered throughout the timbered areas suffered a burning of the foliage. Although some trees were almost completely defoliated as a result of this injury, in most of the trees that were affected the damage was confined to the top. This type of injury did not occur following the winter of 1932-33. For that reason some of the most severely injured trees were examined to determine the nature of the injury. In some of these trees, the cambium had been injured and was becoming brown when seen in April. Most of the trees so affected were thin barked and relatively small although a few were about twenty inches in diameter. All such trees as were examined became infested later in the season, but it was evident that they were dead before the insects attacked them. In many trees the injury was confined to the foliage. If buds had not been killed, defoliation was followed by the production of new needles during the summer of 1937.

EFFECTS OF LOW TEMPERATURES ON SUBSEQUENT INFESTATIONS

Season of 1933: Studies of the effect of the low temperatures of the winter of 1932-33 on the infestations of the following summer indicated what might be expected in 1937. Field studies of brood mortality (3) and analyses of samples of infested bark that were made in the spring of 1933 (1) showed that the brood mortality was similar in both years. Furniss' (2) study of the western pine beetle during the 1933 season showed just what changes took place in infestation conditions of the season following the freeze. His results may be summarized briefly as follows:

1. The so-called primary species least affected by the low temperatures (i.e., flathead borers (Melanophila californica Van Dyke), the mountain pine beetle (Dendroctonus monticolae Hopk.) and Oregon engraver beetle (Ips oregoni Eichh.)) assumed an important role in the early season infestations. They entered into the infestations to a much greater extent than is normal for those species.

2. Western pine beetle populations, which were greatly reduced because of the high winter mortality, were a relatively unimportant factor in forest insect infestations during the early part of the 1933 season.

3. The western pine beetle made a marked recovery during the season, chiefly due to the outbreak tendencies then existing. By the end of the season, the western pine beetle was again a prominent element in the infestation.

Season of 1937: In 1937 similar changes occurred as a result of the reduction of western pine beetle populations. However, the outbreak tendencies present in 1933 were absent in 1937. Although a marked recovery of the species was apparent in the analyses of infested trees that were made in November, it was not as marked ar as complete as it was found to be in the fall of 1933. In 1937 as in 1933 the analyses showed a

predominantly mixed infestation in which several species of forest insects usually were involved in the infestation of each tree. I believe those changes are the direct result of changes in species relations. The changes appear to be chiefly ones of modification of population levels through the agency of low temperatures and mortality of overwintering broods.

In addition to the changes in species relations that appear to be a normal result of temperatures low enough to cause considerable mortality in overwintering forest insect populations, other changes have been noted this season. These changes do not appear to have been a direct result of the effects of cold on overwintering broods. They seem to be an indirect result and due to the creation of an abumdant supply of winter injured host material. Although population levels are known to have played an important part in one of these changes, and may play an important part in the other changes as well, the food relation appears to be the important factor. The changes are modifications in the habits of three species of forest insects that customarily feed on dead of injured host material and usually occur in infested trees, if they occur at all, as a result of previous infestation by other more primary species of forest insects.

ROUNDHEADED BOREER INFESTATIONS IN INJURED CAMBIUM

Roundheaded borers (Graphisurus spectabilis (Lec) and G. obliquus (Lec.)) ordinarily infest the phloem and bark of ponderosa pine trees following attacks by other species of insects. They are considered a secondary species, contributing chiefly to the decay of dead trees by use and destruction of phloem and bark. To some extent, however, they compete with the primary insects for food. Although, during the past seven years of survey and analyses of forest insect infestations in the Modoc, roundheaded borers have occurred in most infested pines, seldom have they been found as the species initiating the infestation in the trees.

In 1937 roundheaded borers were the first species to enter the trees in which the cambium was known to have been injured by cold. They were successful in their competition with broods of flatheaded borers (Melanophila gentilis Lec.) for space so that that species was relatively unsuccessful in the trees. In addition some of the injured phloem area was filled in by Orthotomicus ornatus Sw., Ips oregoni (Eichh.) and other miscellaneous species of insects. Sometimes the phloem on the tree merely died and dried up without becoming infested by either primary of secondary species. This type of roundheaded borer infestation can easily be explained. The phloem in the trees was known to have been killed by cold. The low temperatures merely acted as the factor necessary to produce host material satisfactory for roundheaded borer infestation. Ordinarily other species of insects perform that work by attacking living trees.

Many other trees were found to have roundheaded borer infestations in the upper bole region. Sometimes that infestation followed attacks by other species, which is the normal sequence. However, at other times the roundheaded borer attacks initiated the infestation in the trees. In some trees the entire successful infestation consisted of roundheaded borer broods in the top and turpentine beetle (Dendroctonus valens Lec.) broods in the base as a result of later attacks.

The low temperatures of January 1937 are known to have top-killed (Fig. 1) many trees in the Modoc area. It also is known that quite a few trees that were affected by the cold suffered an injury to the cambium. It has been found that roundheaded borers were the first to attack such trees and that they were successful in infesting the injured cambium. It requires no stretch of the imagination to conclude that it is entirely possible if not probable that many of the tops found to have become infested by roundheaded borer broods alone suffered cambium injury as a result of the low temperatures of January 1937. As a result of the cambium injury caused by unusually low temperatures, roundheaded borers apparently changed their habits of attack and initiated infestations in green trees. This change was one of the unusual developments of the 1937 infestation in the Modoc National Forest.

FLATHEADED BORER INFESTATIONS IN INJURED CAMBIUM

Another unusual development of the 1937 season was the presence of flatheaded borer broods of the species Melanophila gentilis Lec. in the bole areas of infested standing trees. In a few trees gentilis appeared to be the chief species concerned in the infestation. Ordinarily this species only occasionally infests small, practically dead portions of standing trees. It prefers windfalls, snowbreaks or felled trees as host material. A closely related species (M. californica VanDyke) is the flatheaded borer commonly found infesting the bole areas of ponderosa pine trees in the Modoc National Forest.

The nature of the larval galleries of the two species (Figs. 2, 3) has been found to be the best character on which to determine which species of Melanophila is concerned in the infestation. In most of those trees in which gentilis galleries were found the cambium had been injured and was dying when examinations first were made. It is believed that the gentilis infestations also resulted from the winter injury to cambium of living trees and that the apparent change in the habits of attack of that species is the result of the preparation of suitable host material by the low temperatures of January, 1937.

TURPENTINE BEETLE INFESTATIONS

The third unusual development of the season was a change in the habits of the turpentine beetle (Dendroctonus valens Lec.). This change is the direct result of a high population level which was built up during the past two seasons in the large number of green bases of trees that had been infested by western pine beetle broods. However, the apparent importance of the turpentine beetle during 1937 also seems to be related in part to the effects of the low temperatures on living trees. In many of the completely infested trees valens attacks occurred soon after the first successful attacks by other cambium mining species of insects. Ordinarily valens attacks occur much later in the sequence. In addition some cold injured trees were found in which valens attacked at about the same time the roundheaded borers were infesting the injured tops. In some of the trees that were analyzed, no other species had attacked the main bole successfully although scattered late season attacks were being made by engraver beetles

or by the mountain pine beetle. Whatever the sequence of attack by the several species, it is unusual that valens should occur so early in the succession. This change in the role of the species is believed to be due in part to the high population level and in part to the effects of the low temperatures on the trees that placed them in a condition of high susceptibility equivalent to that of top-killed or injured trees.

In some trees the attacks were of no great importance as the broods were unsuccessful. In many of the trees the broods were not only successful but extended for some distance up the bole (Fig. 4). In the event the latter condition occurred there is little doubt that valens played an important role in the succession of insect attacks leading to the death of those trees.

SUMMARY

Analyses of the trees that were infested during the 1937 season in the Modoc National Forest demonstrated that changes had occurred in the habits of attack of three species of forest insects. Those changes seem to have resulted from the effects of the low temperatures of January 1937 on living green trees.

In many trees in the Modoc National Forest the temperatures burned foliage, injured cambium and apparently caused a top-killing of many otherwise green trees. Roundheaded borers attacked the areas of injured cambium and were successful in producing broods. In many trees the roundheaded borers were the first to attack, a habit not usually associated with the species. Ordinarily they attack following the infestation of standing trees by other, more primary, species.

In several trees Melanophila gentilis Lec. broods developed in the boles of standing trees. Ordinarily this species prefers different host material. This unusual type of infestation is believed to be due to cambium injury caused by low temperatures and to a lack of competition by other secondary species of insects.

A high population level of the turpentine beetle has been built up over the past two years as a result of an abundant food supply. This season the cold injured trees appeared to have been weakened to the extent that valens was able to secure a position of priority in the sequence of attacks leading to death of those trees. This position is much earlier in the succession than that customarily filled by the turpentine beetle.

Berkeley, California.
December 23, 1937.

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4. Salman, K. A.
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   Reconnaissance of 1936-1937 Winter Mortality of Forest Insects in California. May 26, 1937.

Figure 1.

Mature tree in which foliage was injured by low temperatures of January 1937. Many such trees were subsequently top-infested by roundheaded borers. Modoc National Forest, California. August, 1937. K. A. Salman. 10121D.

Figure 2.

Larval gallery of Melanophila gentilis in bole of ponderosa pine weakened by low temperatures of January 1937. Compare with figure 3 and note long winding gallery entirely in phloem, lack of wood scars indicating attack after tree growth ceased and gradual widening of larval mine. Modoc National Forest, California. October, 1937. K. A. Salman. 10125.

Figure 3.

Larval gallery of successful Melanophila californica attack in bole of ponderosa pine not weakened by low temperatures of January 1937. Compare with figure 2 and note wood scar indicating attack at least a year before growth of tree stopped, and sudden widening of gallery when attack became successful. Modoc National Forest, California. October 1937. K. A. Salman. 10129.

Figure 4

Successful Dendroctonus valens attack in lower bole area of tree #60 analyzed in Nov. 1937. Top had previously been attacked by flathead borers (Melanophila californica) that had become successful during the summer of 1937. In addition some foliage injury had resulted from the low temperatures of January 1937. Apparently M. californica was successful first in the sequence of attacks. D. valens was second in the sequence and mountain pine beetle adults were attacking the mid bole section at the time the analysis was made. Modoc National Forest, Calif. October, 1937. K. A. Salman.